

# **ID Control System**

## **Cross Training**

### **The Basics**

# What is an Insertion Device ?

## ■ Insertion Device (ID):

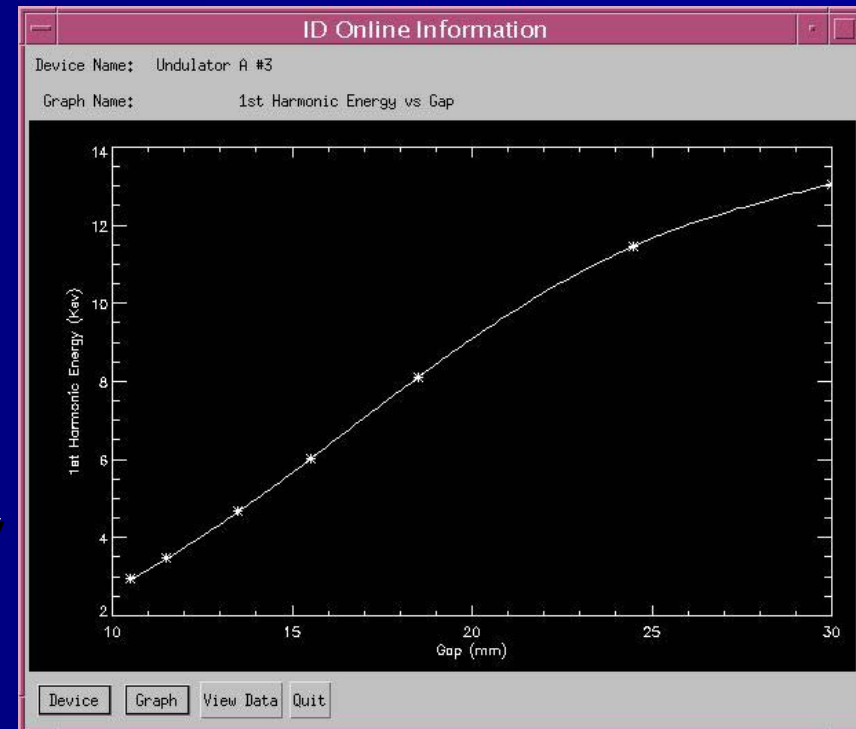
- A device which “inserts” a magnetic field into the particle beam path causing multiple bends in the particle beam, thus producing higher intensity X-Rays than that of a bending magnet beamline.

## ■ Typical IDs at APS:

- Contain an array of permanent rare earth magnets mounted on movable jaws that are able to be positioned to within about 50 microns of the storage ring vacuum chamber straight section.
- Magnetic fields of about 1 tesla can be achieved at minimum gap.

# Why Control The IDs ?

- Changing the ID gap causes changes in the magnetic field in the particle beam path thereby changing the x-ray spectrum for the beamline



# Types of IDs at APS

- STI Device:

- A 2-stepper motor ID with the top and the bottom jaws coupled together by chains and gears; built by STI Optronics.

- NGSM Device (**New Gap Separation Mechanism**):

- A 4-stepper motor ID with each motor controlling each end of 2 separate jaws simultaneously.
- Each jaw containing a magnetic array.

- Typical gap movement 11mm ~ 180mm

# Types of IDs at APS (continued)

- EMW Device (Elliptical Multipole Wiggler):
  - A 2-stepper motor ID with the top and the bottom jaw being controlled separately. Permanent magnets in the vertical plane and electromagnets in the horizontal plane.
  - Normally operated at a 24mm gap (sector 11)
- CPU Device (Circularly Polarized Undulator):
  - A fixed gap ID with only electromagnets.
  - Sector 4

# Installed IDs at APS

- Currently 20 2-motor (STI) devices, 7 4-motor (NGS) devices, 1 CPU device, and 1 EMW device.
- Total of 29 insertion devices located in 26 sectors around the storage ring.

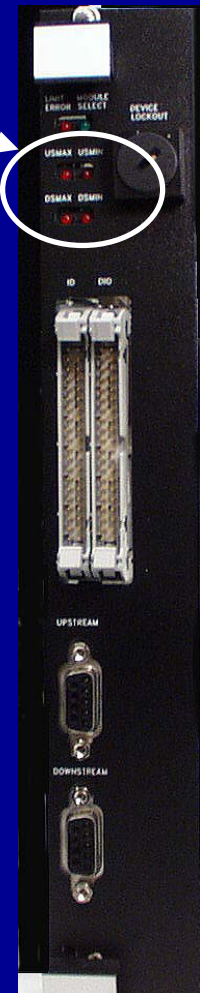
# ID Control System Interlocks

## ■ Limit switch logic

### — How it works:

- A minimum limit hit at one end stops that end from closing any further while inhibiting opening of the opposite end of the ID
- A maximum limit hit at one end stops that end from opening any further while inhibiting closing of the opposite end of the ID
- Prevents ID from crushing the vacuum chamber
- “Hard wired” limit switches remove AC input power from the stepper motor drives

Inhibited motion



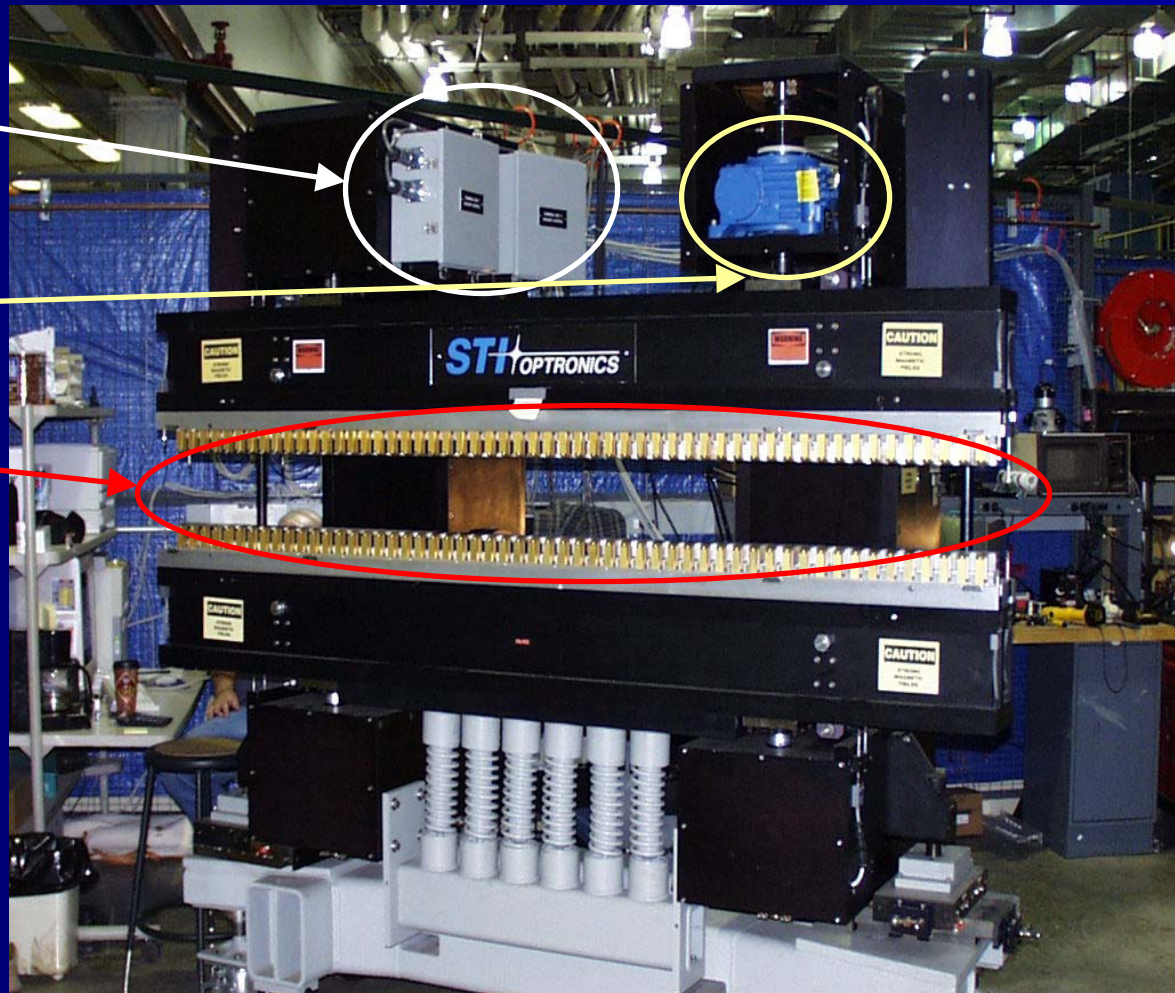
# STI Insertion Device

ID wiring interface boxes

Gearbox

Magnetic array

2 motors run each end of this device





# NGSM Insertion Device

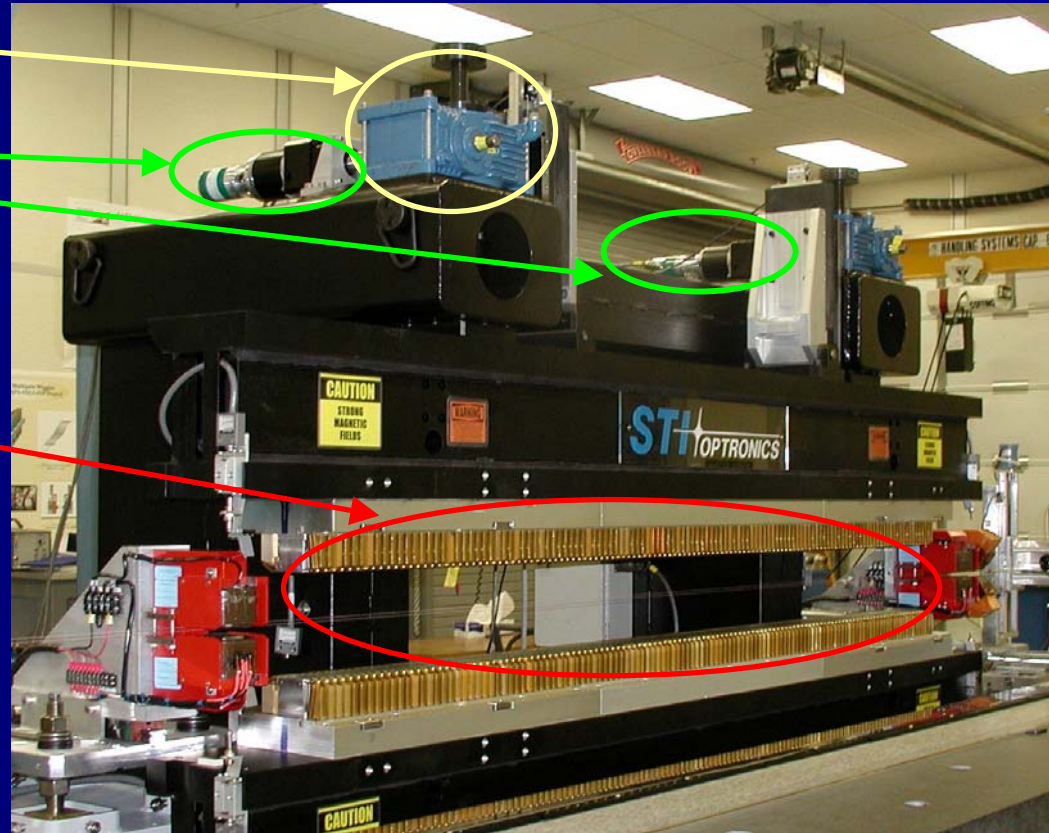
Gearbox

Rotary encoder &  
motor assembly

Magnetic array

4 motor device:

Each stepper motor controls  
each end of each jaw

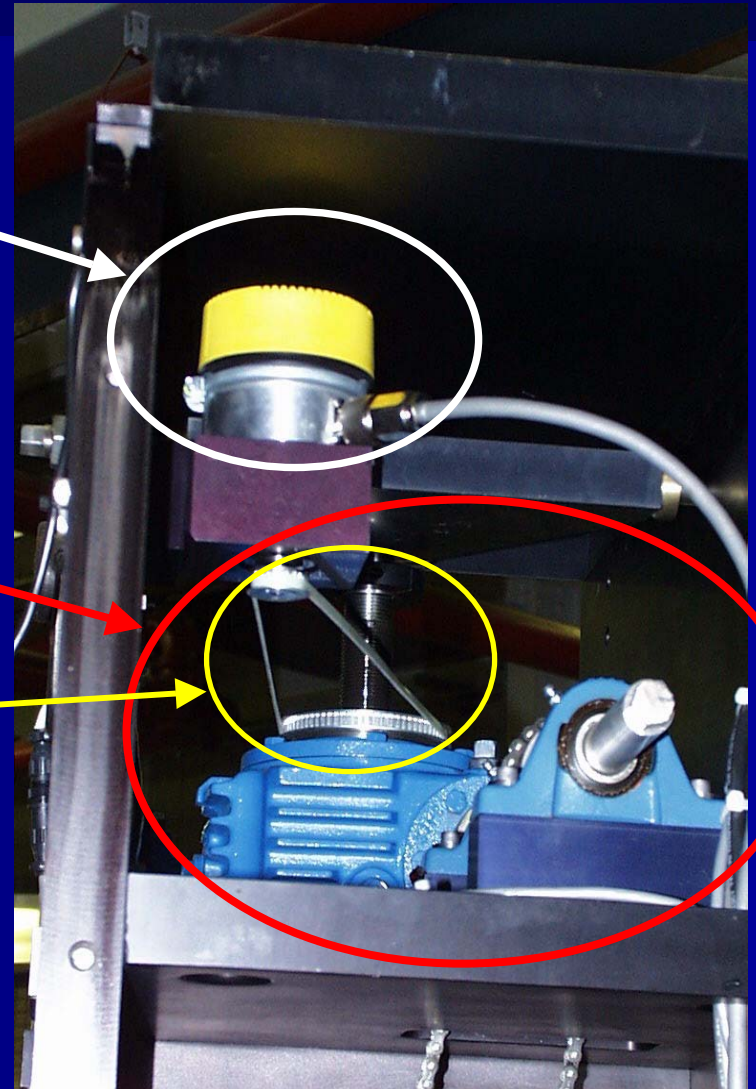


# STI Insertion Device

Stegmann rotary encoder  
(SSI Output)

ID jaw drive mechanism  
and encoder belt

Encoder drive belt



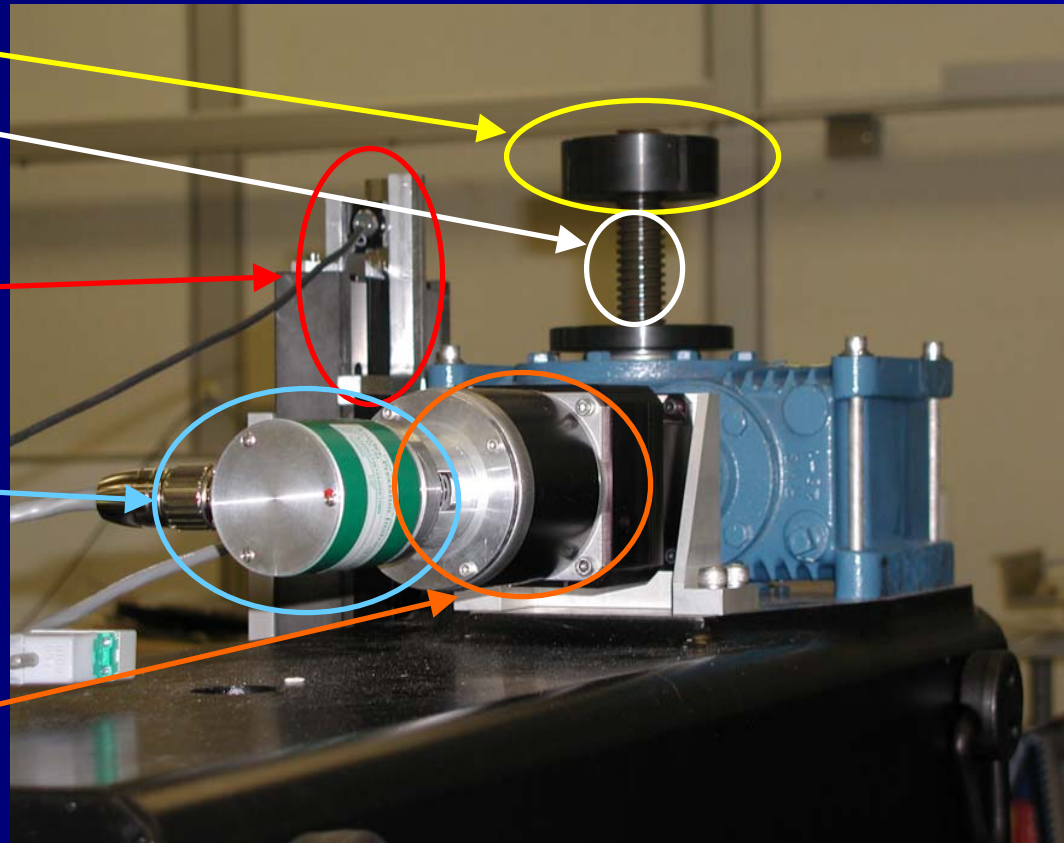
# NGSM Insertion Device

Minimum gap hardstop  
ID jaw drive screw

Gurley linear encoder

Gurley rotary encoder

Stepper motor





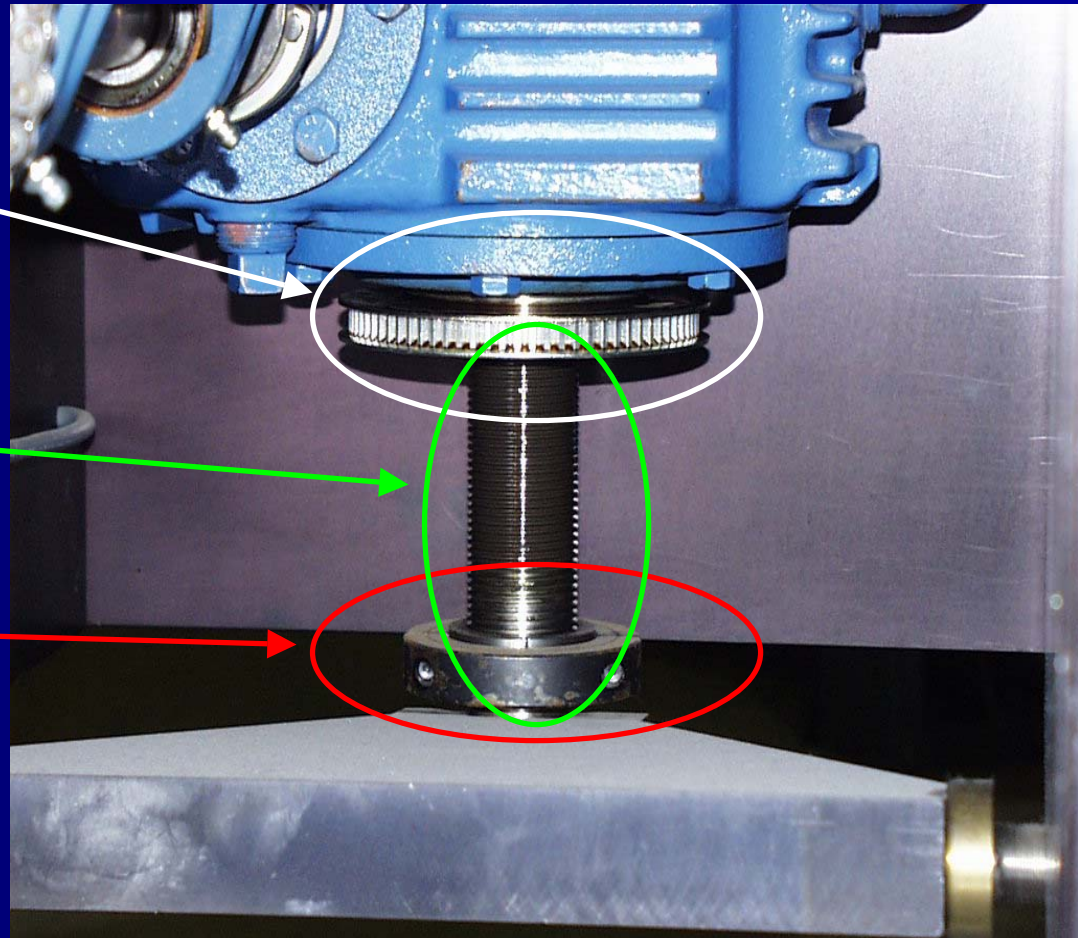
# STI Insertion Device

Rotary encoder drive  
belt and gear:

Uses a plastic belt

ACME drive screw

ID hard stop



# STI Gap Separation System

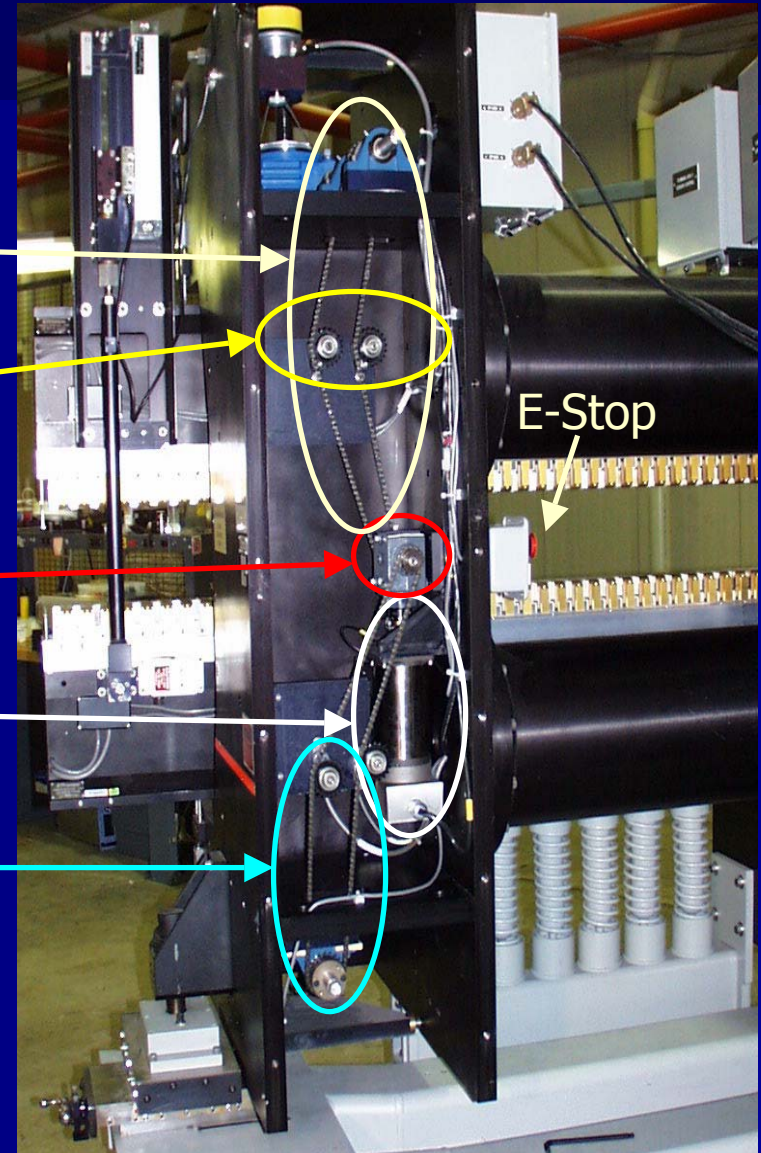
Upper jaw drive chain

Chain tension adjustment

Gearbox

Stepper Motor

Lower jaw drive chain



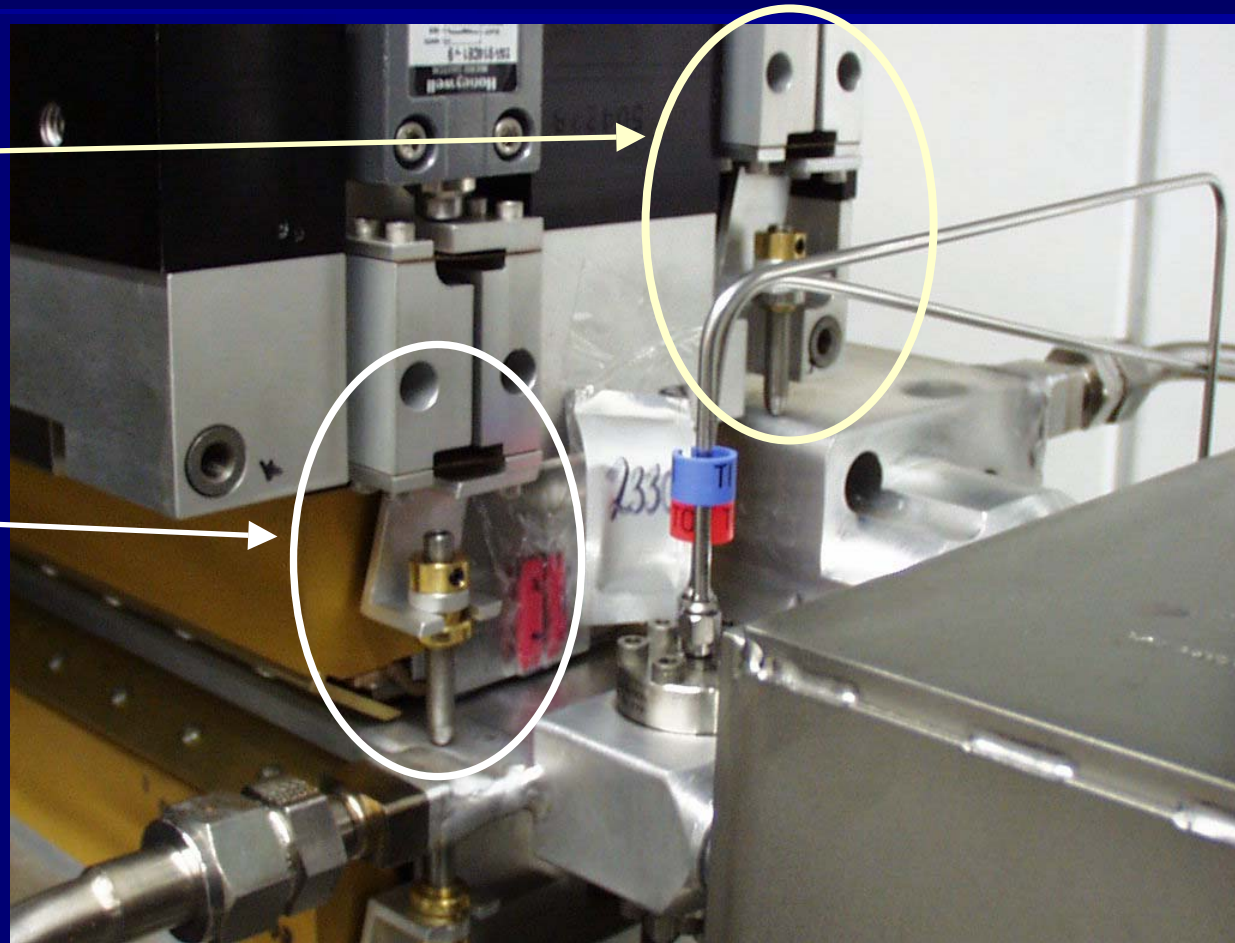
# Minimum ID Limit Switches

Minimum limit switch:

Stops this end from closing

Minimum limit switch:

Shuts off AC stepper motor drive power





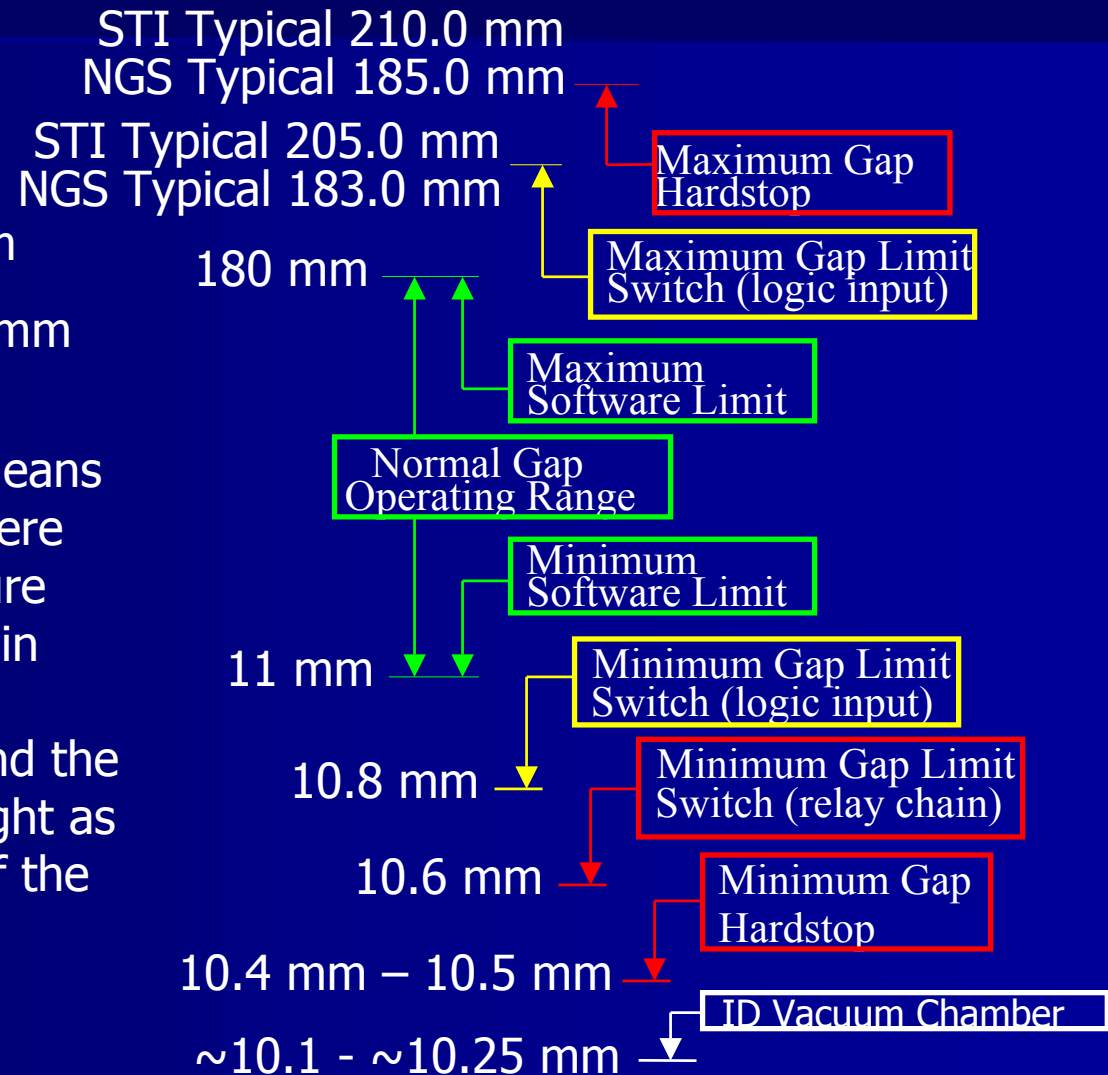
# ID Safeguards & Operating Ranges

## ■ Typical operating ranges:

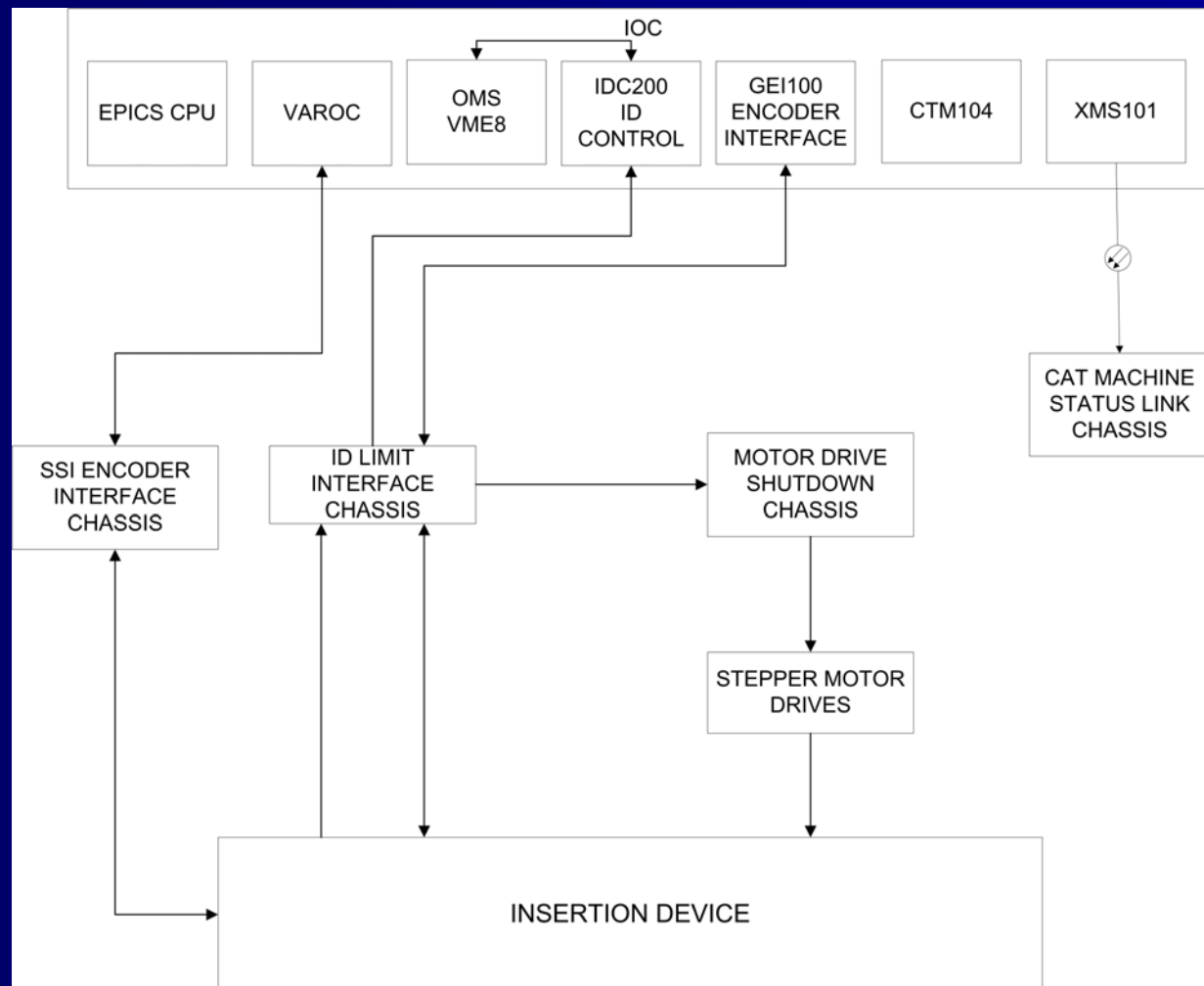
- STI Device 10.5 – 210mm
- NGSM Device 10.5 – 180mm

■ The nominal ID gap is set at specified magnet poles. This means that due to magnetic tuning there may be spots along the structure that are higher by 100µm. So, in some cases the total clearance between the magnetic array and the vacuum chamber may be as tight as 25µm (0.001") to either side of the chamber.

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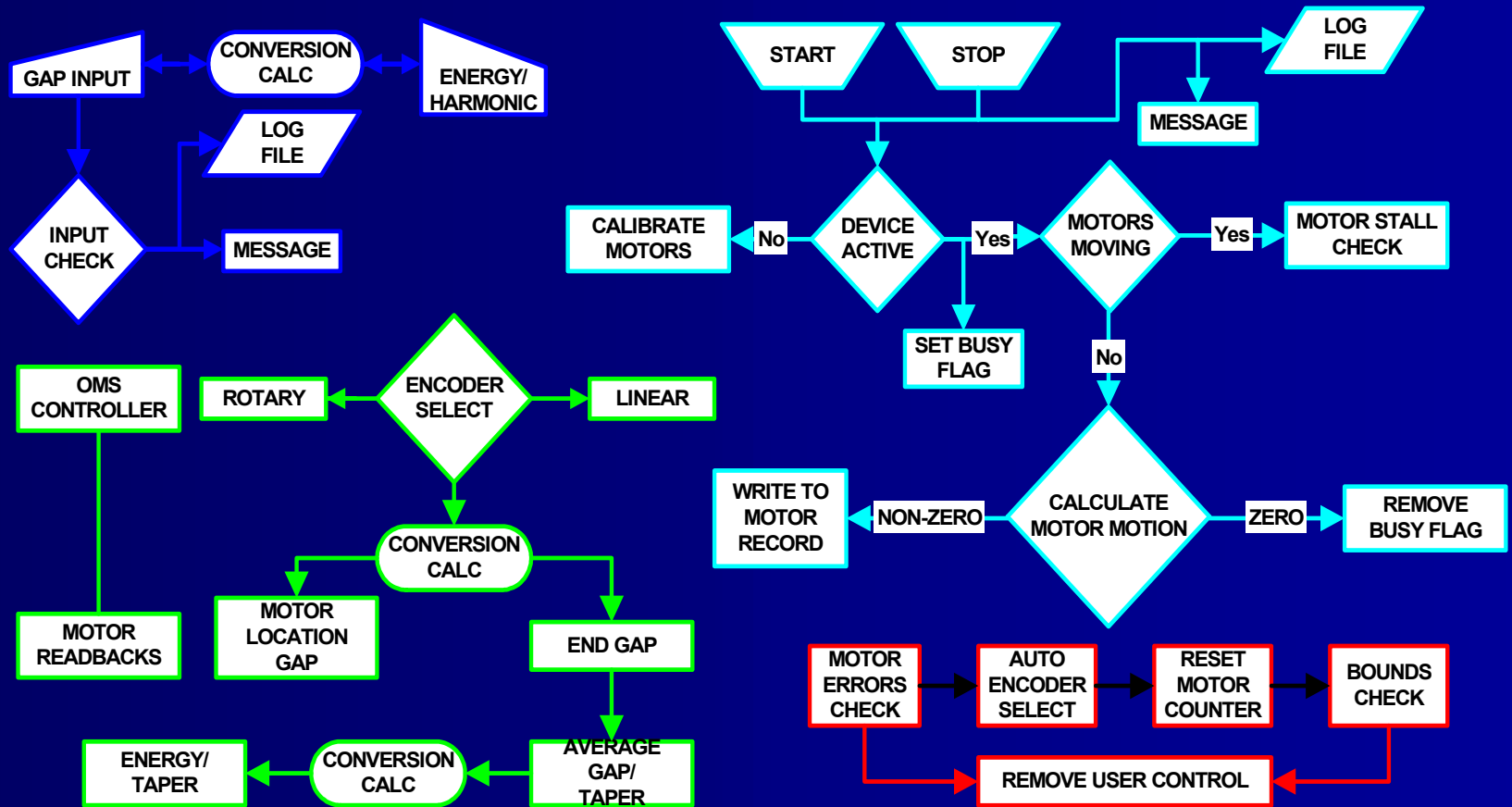
# Hardware Block Diagram



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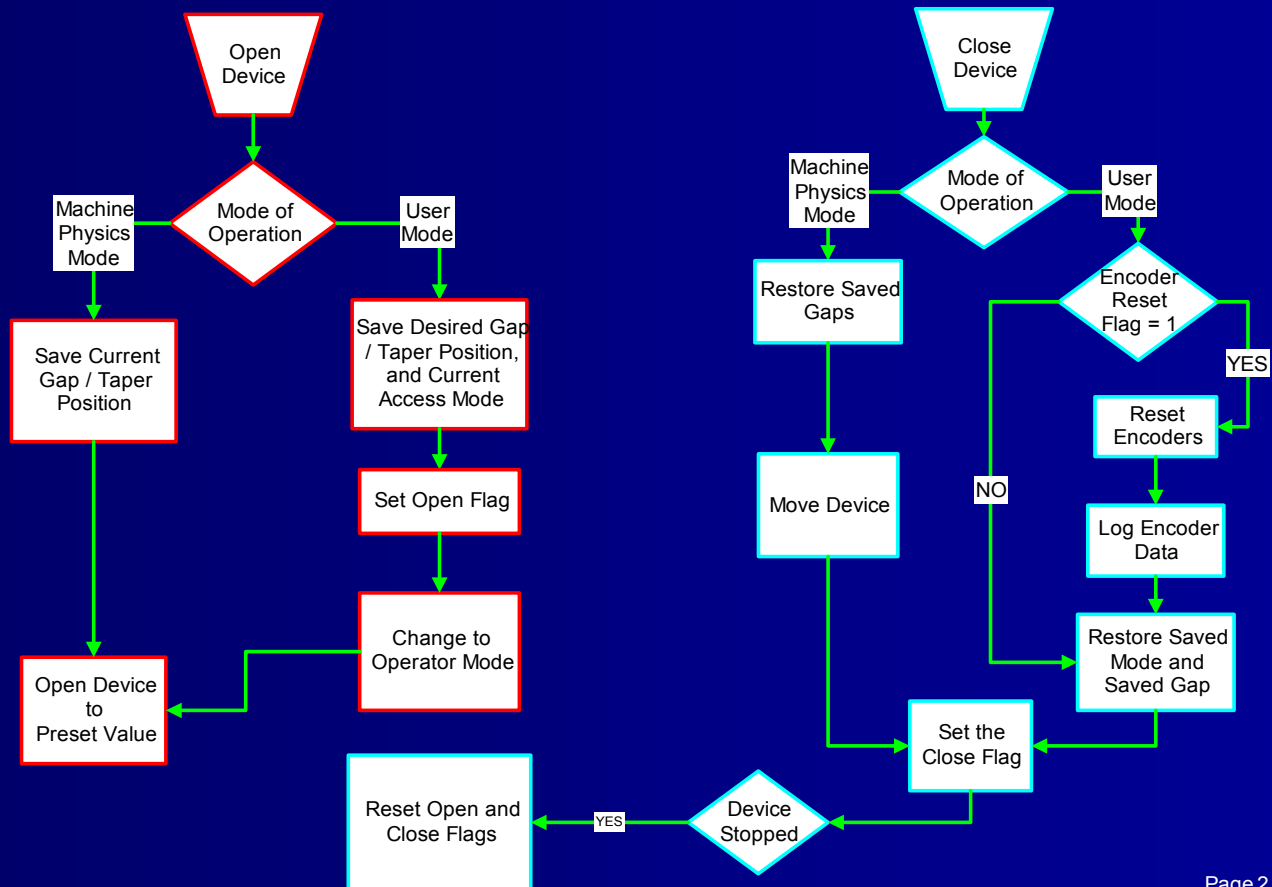


# EPICS Databases

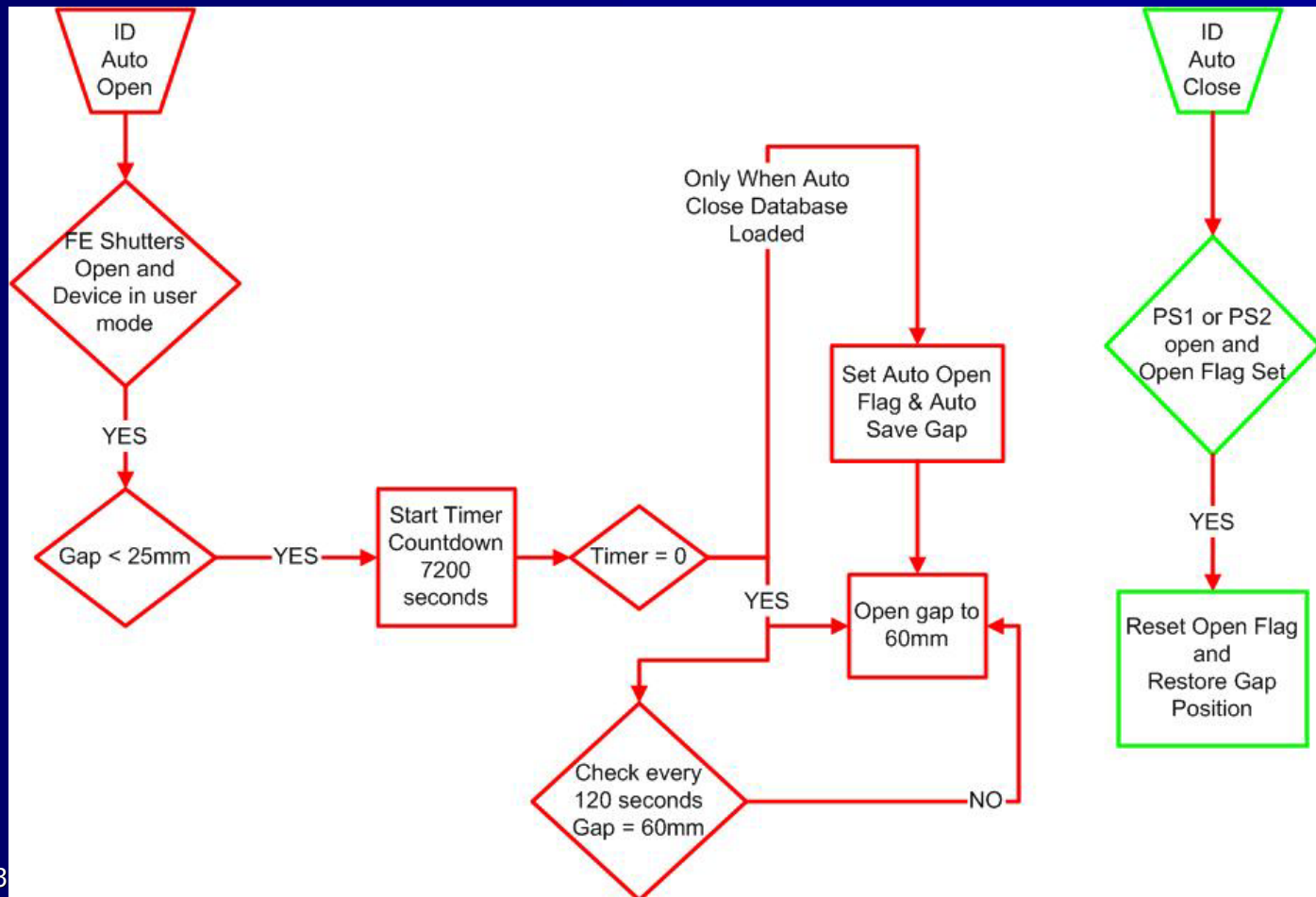


# ID Global Open/Close

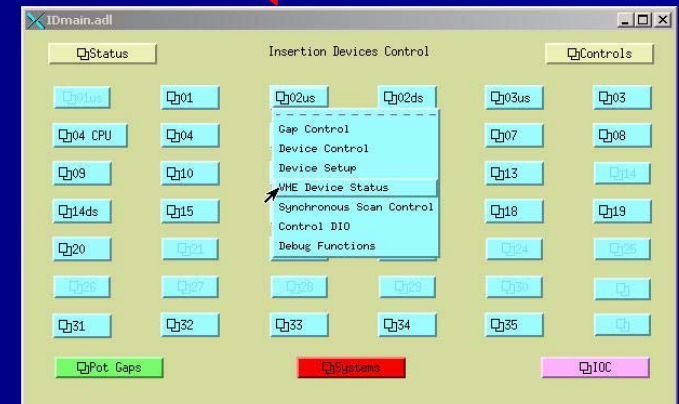
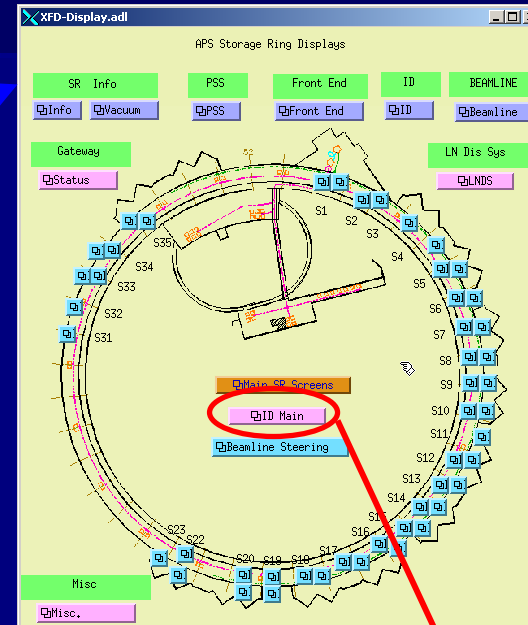
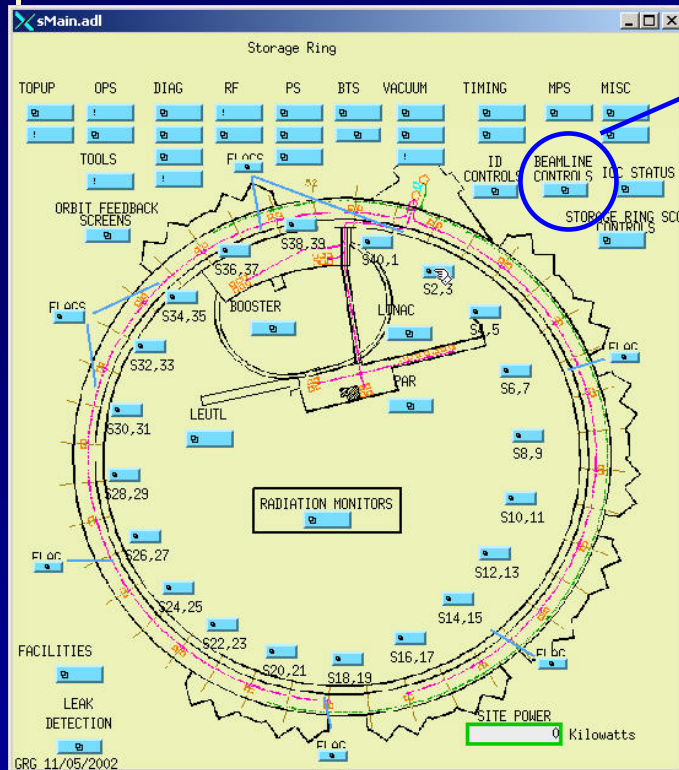
## Global Open / Close



# ID Auto Open/Close



# Navigating Displays



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# ID Control Status

Desired gap/taper position.

Gap/Energy conversion status.

ID control messages.

Encoder selection.

Motor record VAL fields.

When ID is "Global Busy" movement may only be done by using the "Raw Controls".

The ID can only be moved using the normal controls when "Operational".

The screenshot shows the 'ID System Manager Control' window. Annotations include:

- A white arrow points from 'Desired gap/taper position.' to the 'Position' field (160.000 mm).
- A blue arrow points from 'Gap/Energy conversion status.' to the 'Conv. Messages' field.
- A blue arrow points from 'ID control messages.' to the 'Error Messages' field.
- A magenta arrow points from 'Encoder selection.' to the 'Encoder Select' buttons (Linear, Rotary).
- A white arrow points from 'Motor record VAL fields.' to the 'Motors Set' fields.
- A red arrow points from 'When ID is "Global Busy" movement may only be done by using the "Raw Controls".' to the 'Raw Controls' section.
- A blue arrow points from 'The ID can only be moved using the normal controls when "Operational".' to the 'Operational' status indicator.

**Raw Controls** section details:

	Upstream	Downstream	All Motors
Motors Set	160.0135	160.0173	0.000
Calibrate	20 microns	Calib Motors	Stop Motors
Rotary Enc	Operational	Operational	

# ID Control Status

Stepper motor drive status.

"Boost On" indicates motor controller step output is active

Stepper motor axis selection must change motor record axis if this is changed.

Limit switch status, which switch is being hit.

Minimum limit switch lockout enables the device to open when hitting min. limits.

Hardware status and motion lockout.

The screenshot displays the 'ID Control Status' window (4.1) for 'Sector #02 Upstream ID' and 'Device: Undulator\_#20\_3.3cm'. The interface is divided into several sections:

- Upstream Section:**
  - Axis: R-Axis (Selected)
  - Select: R-Axis
  - RSF Encoder Reset: Not Reset
  - Limit Status: Max Limit UJ, Min Limit UJ, Max Limit LJ, Min Limit LJ (all green)
  - Drive Boost Status: Boost Off
  - Drive Reduce Status: Reduce On
  - Motor Stopped / Drive On buttons
  - Start Reset / Reset Complete buttons
- Downstream Section:**
  - Axis: S-Axis (Selected)
  - Select: S-Axis
  - RSF Encoder Reset: Not Reset
  - Limit Status: Max Limit UJ, Min Limit UJ, Max Limit LJ, Min Limit LJ (all green)
  - Drive Boost Status: Boost Off
  - Drive Reduce Status: Reduce On
  - Motor Stopped / Drive On buttons
  - Ready to Operate status
- Gurley Encoders Section:**
  - Upstream: Clear (OK), Reset (OK)
  - Status: Quad Error, Analog Error, Sync Error (all green)
  - Downstream: Clear (OK), Reset (OK)
- ID Control Section:**
  - Device Disabled: Enabled
  - Device Enable: Normal
  - Emergency Open OK: Normal
  - Normal Open: Normal
  - Force Open: Steps On
  - Steps On: Steps On
  - Steps Off: Steps On
- ID Hardware Status Section:**
  - Allow Move: EPS Allow Move
  - Emerg Open: Normal
  - ID E-Stop: Not E-Stopped
  - Cont E-Stop: Not E-Stopped
  - Device Enbl Key: Device Enabled
- AWO Status Section:**
  - Motor On
  - Limit Lockout: Disabled
  - Limit Error: Limits OK

Annotations on the image include:

- A red circle around the 'Boost Off' and 'Reduce On' status indicators in the Upstream section.
- A blue circle around the 'Max Limit UJ' and 'Min Limit UJ' indicators in the Upstream section.
- A blue circle around the 'Max Limit LJ' and 'Min Limit LJ' indicators in the Downstream section.
- A red circle around the 'ID Control' and 'ID Hardware Status' sections.
- A blue circle around the 'Limit Lockout' and 'Limit Error' indicators in the AWO Status section.

# COMMON FAILURES

- User is unable to control the ID gap.
  - The control is in “System Manager” & “Global Busy” mode.
  - PV gateway access security needs to be changed.
  - CAT may have made network changes. If so what was changed ? Netmask, user name, machine name, etc.
- ID is in “System Manager” mode
  - The control “thinks” the ID went out of bounds.
    - Usually an encoder error (may be transient).
- Why is my ID at a gap of 60mm ?
  - The front end shutters were closed and the ID was at a gap less than 25mm for more than 2 hours. ID auto open database moved the device.
  - The AB link is down to the FE IOC and FE shutter position cannot be updated. (Last known shutter state was closed.)

# More Information

- ID Control hardware information
  - <http://www.aps4.anl.gov/id/idcontrol.html>
- ID activity log files
  - [http://www.aps4.anl.gov/user\\_operations/bin/IDlogs\\_list.pl](http://www.aps4.anl.gov/user_operations/bin/IDlogs_list.pl)
- PV Gateway Status
  - <http://www.aps.anl.gov/aod/blops/status/pvGatewayStatus.html>
- Troubleshooting Common Problems
  - [asdctls\documentation\online systems\id fe\tutorial\Insertion Device Control System Troubleshooting.doc](#)



# ID Control System Publications

## ■ Publications

### – VME insertion device control at the APS

■ \asdctl\documentation\online\_systems\id\_fe\Papers\RSI01454.pdf

### – Overview of insertion device controls at APS

■ \asdctl\documentation\online\_systems\id\_fe\Papers\RSI01448.pdf

### – Insertion device operating experience at the APS

■ \asdctl\documentation\online\_systems\id\_fe\Papers\RSI01433.pdf